HOMES: THE HOUSING OFFICE MOVE-IN ESTIMATING SYSTEM

THESIS

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THESIS

Presented to the Faculty of the School of Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the degree of

Master of Science in Engineering Management

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Captain, USAF

September 1988

Preface

The purpose of study was to develop an accurate and user friendly computer program to forecast waiting time for military family housing.

The model was developed on a spreadsheet and achieved both goals. The algorithm will be incorporated in the civil engineering WANG mini-computer by the Engineering and Services Center and distributed Air Force wide.

I have had a great deal of help in preparing this thesis. A big thanks goes to my advisor, Major James R. Holt, who knew what I was going through and enthusiastically supported me along the way. I would also like to thank Ray Grimm of Patrick AFB for taking time out of his busy schedule to listen to my ideas and incorporating them into his computer program. Finally, I wish to thank my wife, Cindy, and my two little ones who understood on those long nights and weekends when I was bound to the computer.

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Abstract

The purpose of this study was to utilize a forecast method for estimating waiting time for Military Family Housing. The study had two basic objectives. The first was to accurately forecast waiting time for each classification of Military Family Housing and the second was to create a user friendly, statistically based computer program to implement the forecasting technique.

The study surfaced three quantitative methods that forecast waiting time successfully: Seasonal indexing, adjusted seasonal indexing, and monthly averaging. Analysis proved that these three methods were the most accurate of the forecasting methods tried and any one should produce satisfactory forecasts.

Monthly averaging was the method chosen for the forecasting model. That particular method was chosen for its accuracy and relative simplicity of the calculations. Monthly averaging worked well because there were virtually no trends in the assignment process. The two indexing methods utilize regression analysis for the forecast and when there is a zero slope, the forecast value is practically identical with the average.

The model runs on VP Plus, a spreadsheet that is IBM

compatible. The use of macros within the spreadsheet make the program user friendly. The spreadsheet template is configured for Wright-Patterson AFB OH, but may easily be adapted to any other base with similar waiting lists.

Ray Grimm, WIMS Systems Director for Patrick AFB, in conjunction with the Air Force Engineering and Services Center, is currently using the algorithm as a bases for writing a COBOL program for use on the WANG computer.

HOMES: THE HOUSING OFFICE MOVE-IN ESTIMATING SYSTEM

I. Introduction

Problem Overview

The assignment of a house from the Military Family Housing Office effects all active duty married military who desire to live on base. The military member may, by r-gulation, apply for on-base housing thirty days before the month he arrives at his new duty station. The Housing Office estimates how long he will have to wait before on-base housing is available and assigns the member to a waiting list. If the waiting list is short or empty, the military member should have a house assigned to him fairly quickly. However, if the housing waiting list is long, he may have to wait several months or even years before he is assigned a house.

Housing officials are often frustrated in trying to make accurate estimates of waiting times. Currently, housing personnel have a "feel", based on experience, when houses will come available for people in different positions on the waiting list.

There are few systematic methods to support their feelings. "One big problem is that two different [housing officers] may give different waiting times for the same class

of housing on the same day" (13). For example, Airman Smith has just arrived at the base and added his name to the waiting list. He was told by housing officer A that he has a six month wait. On the same day Airman Jones places his name on the same list and is told by housing officer B that there is a nine month wait. Both housing officers are giving their best estimate, but different. There are presently no analytical methods utilized for estimating the accurate waiting times. Any current estimate of wait-time made by the housing personnel is merely an educated guess. There are frequently large discrepancies in the amount of time actually spent on the waiting list compared to the initial estimates, either too long or too short. This disparity remains a major area of complaints for the housing office. Nobody likes to wait for a house to come available, but if the newcomer could rely on the estimate made by the housing officer, then he could make appropriate plans until a house did come available.

An up-to-date statistical analysis package that uses the available historical data could accurately forecast waiting duration and could be easily used by housing officers. Historical data kept by the housing office is archived and not referred to again for forecasting purposes. This record of daily assignments and terminations is an excellent data base from which a forecast can be made.

Research Problem

This research will attempt to create a user friendly statistical computer program using historical data to demonstrate the possibility of forecasting MFH waiting time.

Investigative Questions

To complete this study, the following questions must be answered:

1. What data should be gathered?

2. What is the most appropriate forecasting method?

3. Can knowledge of firm move-out dates and lease commitments be used to improve the forecast?

Justification for Study

The military member, new to the area, needs to quickly settle his family for several reasons. He can spend more time on the job rather than deciding on adequate housing. He will perform better when he does not have the outside distractions.

The serviceman must make a decision whether to buy a new home, rent a house or apartment, or live on base. Better plans could be made if the waiting time for base housing was accurate. The option to buy a home is always open, but sometimes the economy, the length of stay, or even personal preference drives the new arrival away from a home purchase.

For example, if a serviceman moved to Bolling AFB,

located in Washington D.C. The average price of a home in 1986 was $156,100 (3:459). Rentals in the area are also expensive. According to the Joint Armed Forces Housing officials, the average two bedroom apartment is $800 (11:1). The Variable Housing Allowance (VHA) is greater, but the higher rent usually causes the serviceman to move further away from the city to less expensive lodging. This causes a much greater commuting time, extra expense for vehicle operation, and less time with his family.

Other communities may be small and have an inadequate quantity of housing. If rent is affordable, the quality of life may be below what the service member is accustomed.

A major cause of complaints of the housing office is the lack of accuracy and perceived fairness in assigning houses (10). One may be given a waiting time of one year. Other lodging plans were made for the year; six months later he was offered a house. Housing customers would be more satisfied if they knew within a given range of time when they could move into base housing. If he was initially told the wait would be five to seven months, he could have made the appropriate plans to accommodate those times. The more accurate a waiting time, the more satisfied the housing customer.

The newcomer has an abundance of worries. He has to in-process and start a new job. Many times, the new arrival does not have the luxury to take much time off to look for

adequate housing. With all of the stress involved in moving, the serviceman might have trouble getting a good start in his new job. The added stress of his family's well-being could adversely affect his job performance and his health.

There are many reasons why accurate forecasting is needed. Application of available computer technology can help housing managers estimate. Waiting time should be analytically derived through a statistical means and a look at the existing data base.

Scope

This research effort will use the data collected for Wright-Patterson AFB which can be easily extended to other bases.

II. Background Review

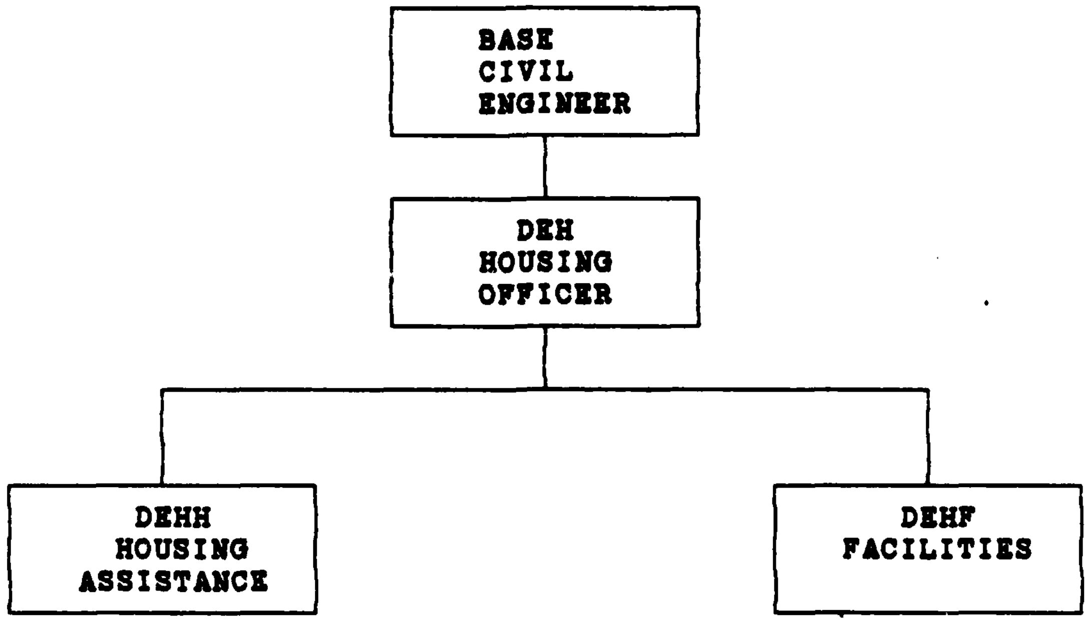
Air Force Regulation (AFR) 90-1 serves as the guideline for the Military Family Housing Office. According to AFR 90-1 "The policy of the U.S. Government is to rely on private community assets as the primary means for housing military families" (4:10). This statement implies that there will never be enough on-base housing for all eligible military members. Therefore, there is a good chance there will be some kind of wait for base housing where economic and social pressures encourage on base living.

The Military Family Housing Office is the focal point for all military housing whether on or off base. Military housing managers

> Manage assignment and termination of MFH...Provide assistance to DoD personnel seeking adequate and desirable housing...ensure maximum occupancy of all assigned housing units...maintain and publish housing waiting lists. [4:12]

Housing Office Organization

The housing office was reorganized in 1984 to better utilize personnel and broaden opportunities for job advancement. The Family Housing Manager administers the two divisions of the housing office: Housing Assistance and Facilities Sections. Refer to Figure 1 for an organizational chart. To understand the housing office and the diversity of its taskings, one must have a working knowledge of each individual MFH function.



(1:B3)

Figure 1. Civil Engineering Housing Organization

Facilities Section

The Air Force Institute of Technology School of Civil Engineering and Services course MGT 406, Family Housing Management Applications Course, outlines the primary goals of the Facilities section. "The primary function of this section is to identify work requirements and ensure all maintenance, repair, and improvements of family housing units and support facilities are accomplished" (1:B9). The particular responsibilities include:

1. Performs initial, prefinal, and final inspections of MFH with prospective and/or current occupants, agent or contractor.

2. Develops and maintains complete maintenance, repair, and improvement programs for housing.

3. Manages the MFH appliance program.

4. Manage the self-help program.

5. Prepare and distribute the housing brochure and other official information to occupants. [1:B9-B10]

Housing Assistance

The Housing Assistance section is mainly concerned with housing occupants both on and off base. "The primary function of this section is to provide competent, and courteous assistance to military members seeking adequate and desirable housing for their families" (1:B4). Housing Assistance has a broad array of responsibilities:

> 1. Manages occupant assignment and termination of MFH, leased dwellings, mobile home parks, rental guarantee housing (RGH), including scheduling inspections. Prepares financial documents affecting the withholding and reinstatement of basic allowance for quarters (BAQ), variable housing allowance (VHA), rental plus and temporary living allowance (TLA).
>
> 2. Obtains and maintains the optional number of nondiscrimatory rental and sales listings...
>
> 3. Establishes and maintains continuous liaison with community officials and civil organizations to stimulate community support in private housing where need exists.
>
> 4. Provides information and performs counseling for both government-owned and private housing...
>
> 5. Mediates landlord-tenant disputes...[1:B5-B7]

The Housing Assistance Section is the section that currently estimates waiting times and has the greatest need for an accurate estimating system. An easy to use system may liberate time to accomplish other activities while increasing

customer satisfaction.

Actual Housing Assignments

The Housing Assistance section administers the assignment process and waiting lists. They acquire guidance from AFR 90-1. "Eligible military personnel not immediately assigned family housing are placed on the housing waiting list, by housing category and bedroom requirement..." (4:16). Personnel are authorized to be assigned to waiting lists determined by their rank (Figure 2) and/or the number of bedrooms depending upon their family size (Figure 3). Whichever table results in the largest number of bedrooms is applicable. For example, a captain with a wife and three teenage children would be eligible for two bedrooms from Figure 2 and a four bedroom house from Figure 3. The captain would be eligible for a four bedroom house because of the size of his family. The usual determining factor for the number of bedrooms is the number of dependents except for those with rank of O-6 and higher where the grade entitles them to at least four bedroom housing.

Waiting lists for MFH are established according to Figure 4. The waiting list assigned is determined by Figures 2 and 3. Eligible members may apply for base housing in advance or wait until arrival at the new base. Advance applications place the individual on the proper list on the first day of the month preceding his expected arrival date. For example, if the expected arrival date is the twentieth of

BEDROOM AUTHORIZATION				
Housing Categories	Grades	2 BR	3 BR	4 BR
General Officers	0-10,0-7			X
Senior Officers	0-6			X
Field Grade Officers	0-5,0-4		X	
Jr. Grade Officer	0-3 thru 0-1 W-4 thru W-1	X NOTE	X*	
Senior NCO	E-9 thru E-7		X	
NCO	E-6 thru E-4	X NOTE		

Figure 2. Bedroom Requirements Based on Grade

NOTE: Personnel with a spouse are placed on the 2-BR waiting list but are given the option to accept 1-BR housing, if desired, when it becomes available.
*W-4s are authorized a 3-BR. (4:17)

June then the person would be placed on the list on the first of May with advance application. If one waits until he arrives then he is considered a "walk-in" and is put on the appropriate waiting list as of that day (4:17). Each applicant is limited to only one list, except when there are quarters classified as inadequate or substandard in which case he may be on both the adequate and inadequate lists. Once an applicant has been offered a house, he has the option of turning it down. He may also turn down a second house, but then has to wait ninety days before re-applying. The base commander can override any list in cases of hardship or for mission essential personnel (4:14).

Number of Dependents, Excluding Spouse	Number of Bedrooms
None or One	2
Two, except as follows:	2
- one 10 years or over	3
- one 6 years or over and of the opposite sex	3
Three, except as follows:	3
- two 10 years or over	4
- one 10 years or over and other two opposite sex with one 6 years or over	4
Four, except as follows:	3
- one 10 years or over	4
- one 6 years or over and all of the other three opposite sex of the one	4
- two 6 years or over of opposite sex and other two same sex	4
- two 10 years or over and other two opposite sex with one 6 years or over	5
- three 10 years or over	5
Five, except as follows:	5
- two or more 10 years or over	4
- one 10 years or over, with one 6 years or over and of the opposite sex of the other three	5

Figure 3. Bedroom Requirements Based on Family Size & Composition (4:17)

Estimating Waiting Time

Estimating the waiting time is not easy. Many variables affect waiting time. Take a typical example. Captain Rogers is a new arrival and is placed at number 25 on the three bedroom Company Grade Officer's list. The housing officer knows that approximately five homes are assigned in this

Housing Categories	Number of Bedrooms			
	2BR	3BR	4BR	5BR**
General Officer Quarters		X**	X	X
Senior Officer Quarters		X**	X	X
Field Grade Officer Quarters	X**	X	X	X
Company Grade Officer Quarters	X	X	X	X
Senior NCO Quarters	X**	X	X	X
NCO Quarters	X	X	X	X

Figure 4. Waiting Lists

*Only if such quarters exist on an installation within these categories.

**If available within grade category, entitlement to 5 bedroom quarters is bases on number of dependents. (4:14)

class each month. She tells him that there will be a five month wait. A closer look at the list, reveals eight of the applicants have not yet arrived at the base. And, ten are waiting for their leases to terminate. Therefore, eighteen people on the list ahead of Captain Rogers are inactive today. Three other people are in the process of looking at empty military family houses which were just offered to them. Effectively, at the time Captain Rogers was put on the list he was number four. Tomorrow the leases could be up and all the new people ahead of Captain Rogers may arrive.

This example illustrates just some of the variables which are compounded by the twelve to fifteen different waiting lists and area preference limits. The housing officer has to

officer has to weight all of these things when estimating. The large number of continually changing factors clutter and burden the human mind, but can be considered clearly as often as required by a computer program. An accurate means to standardize the wait time forecasts would aid the housing official in making reliable estimates.

Forecasting Model Selection

Several procedures for estimating this waiting time were considered. Each method will briefly be explained below.

There are three general methods of forecasting that involve very different approaches: intuitive methods, causal methods, and extrapolative methods (7:4).

Intuitive Methods. Intuitive methods are based on the individual's feeling for the situation (7:4). These methods are frequently forced on managers causing them to make decisions or forecasts based on their own experience. This is the method currently being used by most housing personnel. Each individual gives an estimate of wait time to the customer, based on how they remember situations in the past. Very little of the actual past data is used. Intuitive models could be more accurate if the housing personnel could get together and make group or consensus estimates for the waiting time.

Causal Methods. Causal methods are based on "... trying to forecast effects on the basis of knowledge of their causes" (7:5). Often, the time lag between cause and effect

is very small and information about the causes often arrive after the effects have occurred (7:5).

A causal method could possibly be considered as a model for the housing wait time. The primary cause of housing turn overs is Permanent Change of Station (PCS) moves. The housing office now has access to the base master personnel file. Therefore, whenever a PCS is projected, the housing office could be alerted and a move-out could be planned. However, because of the many variables and the volatility of the assignment system a forecasting method based on the personnel files would probably be very inaccurate. Many PCS's come with short notice while other come with a longer notice. Frequently, the actual leaving date changes. Secondly, the projected PCSs from personnel are usually just a few months in the future and receive only a few weeks notice. For lists longer than three months, this method would lose its accuracy. In any case, a more reliable method would be preferable.

<u>**Extrapolative Methods**</u>. Quantitative methods are those "...based on the extrapolation into the future of features shown by relevant data in the past. The methods are usually of a mathematical or statistical nature..." (7:5). Some type of extrapolative method should be able to accurately forecast the wait time. Historically, PCSs occur at about the same rates and at the same time each year. This is true unless there are unique factors which will change the number of MFH

units or the demand for MFH such as mission changes, new PCS legislation or some kind of housing construction. If this kind of major change occurs, then the housing officer must rely on intuitive methods until the model can be adapted to these deviations. Since historical data is readily available, the extrapolative methods of forecasting will be examined in further detail.

The first avenue considered was an approach examined in a thesis by Captains James R. Holt and Frederick S. Rawls. Their thesis attempted to use simulation to predict the actual waiting time. They used the specialized simulation language called Q-GERTS (9:24). Their data had to be manually retrieved from several different forms. Holt and Rawls used a small sample of just the field grade and company grade housing classes (9:62). They also had the problem of several forms missing from the files making it impossible to gather all of the desired sample (9:63-64).

Capts Holt and Rawls used a FORTRAN subroutine to accumulate waiting time for each applicant and to calculate the means and standard deviations of waiting times. They created two tables from the values. The first table held means and standard deviations from the actual data and the second table contained means and standard deviations originated from the model. The means of each table were graphed and "...it appears that the two sets of data are significantly different" (9:75). Holt and Rawls had problems

with their model. The model's values fell consistently below the actual values. They concluded by saying "...that the model did not produce satisfactory results to predict waiting times" (9:83). Simulation might still be possible using a different approach.

The majority of PCS moves seem to occur at about the same time each year. It appears to be a seasonal time series problem where several different analytical techniques could be used. Each data point can be collected over time, at set intervals, and qualify as a discrete time series.

Sam Kachigan states, "The major task of time series analysis is to describe the nature of the past variation of a variable in order that its future values can be predicted..." (12:423). According to Robert G. Brown "The forecasting problem is estimating the probability distribution from which further numbers in the sequence will be drawn" (2:21). From that statement, if the probability distribution were known, then it could be extended to the future as a forecast. Kachigan goes on to say, "Consequently, even though we might be able to precisely describe the past pattern of variation of our criterion variable, there is absolutely no theoretical assurance that it will recur in the immediate future" (12:428). Kachigan is saying that even though historical data, values predicted are never guaranteed to be absolutely correct.

"Fortunately, based on empirical evidence, we discover

that things usually happen in the future as they have in the past" (12:428). Time series analysis is an attempt to "...identify and model systematic sources of variation in the series..." (12:450). The ultimate goal is to account for time series variations and accurately forecast future values.

Forecast Method Selection

Forecast model selection is probably the most important step in forecasting. According to Norman Gaither, one reason a forecasting system fails is the "Failure to select an appropriate forecasting method" (6:103). A proper model should minimize error while accurately forecasting future values. Gaither also points out that there are several factors that should be considered when selecting a forecasting method: "cost, accuracy, data available, time span, nature of services, and impulse response and noise dampening" (6:102). All of these factors will be looked at in determining the appropriate forecasting method.

Model Selection Criteria

Many variables need to be considered when selecting a forecast method. The basic procedure outlined by Gaither was implemented.

Cost and Accuracy. In most forecasting models there is a trade-off between cost and accuracy. In the waiting list scenario, the cost of collecting data is minimal and computer resources are available. Buying additional equipment,

software, or hiring additional personnel is not possible. Staying within the boundaries just described, cost is not a factor. Accuracy out weighs cost. A method needs to be selected to be the most accurate for the available resources. Gaither points out that "...in many situations, simple and low-cost forecasting methods tend to provide forecasts that are about as accurate as more complex and high-cost forecasting methods" (6:103).

Data Available. Whether or not relevant data is available is important when selecting a model. A sufficient amount of historical data must be available to make a quantitative forecast. The more data available, the better the forecast.

Time Span. The time span the forecast covers is an important factor when selecting a model. In a short-term model (weeks), forecasts made by time series techniques such as exponential smoothing or moving averages may be adequate. Long range (months-years) forecasts may require regression analysis or seasonalized methods for accurate results (6:104).

Nature of Products and Services. The nature of the product or service may also influence the decision on which method to use. Where the product or service is in its life cycle (introduction, growth, maturity, or decline) will affect the choice of forecasts (6:104).

Impulse Response and Noise Dampening. According to

Gaither, "...how responsive we want the forecasting model to be to changes in the actual demand must be balanced against our desire to suppress undesirable chance variation or noise in the data" (6:104). Impulse response and noise dampening are factors mostly effecting short range forecasts. Since the wait time that needs statistical backing is usually six months or greater, these two factors should not play a large part in forecasting method selection.

Actual Method Selection

The data must be examined with "the object of identifying its structure and producing a precise specification for this structure" (6:13). In most cases the structure will be predictable and a provide a basis for selecting the model. Once the model is developed, then extrapolation of the model is possible to forecast future values.

The possibilities of choosing the appropriate model or even developing a unique model seem almost infinite. However according to Dr. Gilchrist "...it has been found in practice that a very wide range of data can be adequately modeled by a relatively small number of basic models" (7:17).

III. Methodology

The methodology for developing and implementing a forecasting model consists of four main phases: Data collection, selection of a forecasting techniques, implementing the technique with the data, and validating the results with actual data.

Data Collection

The historical data to be used for the model was gathered at the Wright-Patterson Housing Office. The housing office uses one record where the number of move-ins and move-outs by class are collected. The form is an AFLC 1704 Military Family Housing Daily Status Record. The AFLC 1704 lists by name and class the assignment transactions of the day. The record also summarizes how many houses were in maintenance and how many were available. The housing office is required to keep a two year record of the AFLC 1704.

Data Available

Data were collected from January 1984 through July 1988 and summarized in Appendix A. The data are relevant and are good prospects to make a good estimate. The data was collected by months for ease of handling and possible further breakdown for a seasonal forecast method.

Time Span

The required time span varies according to the size of the waiting list and number of houses in each class. Some forecasts may only be three months long making it short term. On the other hand, the waiting time could be two years causing a requirement for a long term forecast. Either way, the appropriate method must be chosen. A single flexible method would be best.

Nature of Products and Services

The housing assignment process seems to be relatively stable. The process is in its maturity stage. In this scenario, the variations should be minimal and follow the seasonal cycle of PCS moves.

Actual Method Selection

Several models were attempted and evaluated by the size of the Mean Absolute Deviation (MAD). The MAD is the average of the absolute differences between the forecast and the actual value. The MAD can be used for any quantitative forecasting technique and is not limited to only regression characteristic or other evaluation methods. MAD is used to measure how closely actual data matches the forecast. If the MAD is large, then there are large variations between the forecasts and actual data. Conversely, if MAD is small then the forecasts closely match the actual data.

Data are available from January 1984 through July 1988.

To compare the different methods, the data from January 1984 through December 1986 will be utilized to create forecast models. Forecasts will be calculated for calender year 1987 using each method and then compared to the actual values. The MAD will be calculated. From the size of the various MADs the best method should be apparent. The models to be evaluated are: simple averaging, monthly averaging, exponential smoothing, seasonal indexing, and adjusted seasonal indexing.

Implementation

Once the forecasting method is chosen, all of the data needs to be brought into the model. The chosen method would utilize data from January 1984 through June 1988 to make forecasts.

Validation

Once the appropriate forecasting technique is selected and the spreadsheet completed, the model will be validated. Validation will consist of comparing the actual values of calender year 1987 to the forecast amounts using historical data from January 1984 to December 1986 in the model. The absolute deviation will be calculated. If the absolute deviation is within two standard deviations, then the forecast is a success.

IV. Results of Methodology

Analysis of Data

The raw data was collected from the housing office via AFLC form 1704. Initially the terminations were collected from January 1984 through June 1988. Even though the number of terminations directly affect the number of assignments, the use of terminations to estimate assignments could be weeks off. There is by necessity a lag time between the time someone moves out and another moves in because of minor maintenance and clean-up. For improved accuracy, the termination data was replaced by assignment data collected for the same period.

Inferences from Data

The data appears to be seasonal. Figure 5 is presented to give the reader a feel for the seasonal attributes of the data. The senior NCO move-ins were picked because the values and variations were neither high nor low. The graph also illustrates how there are really no years where most of the values are significantly higher or lower than any other year.

Figure 6 is a plot of the same data over four years. Most of the averages closely approximate the actual values. Also note that unusually high or low peaks are often followed by an opposite reaction causing the average to be even closer over time.

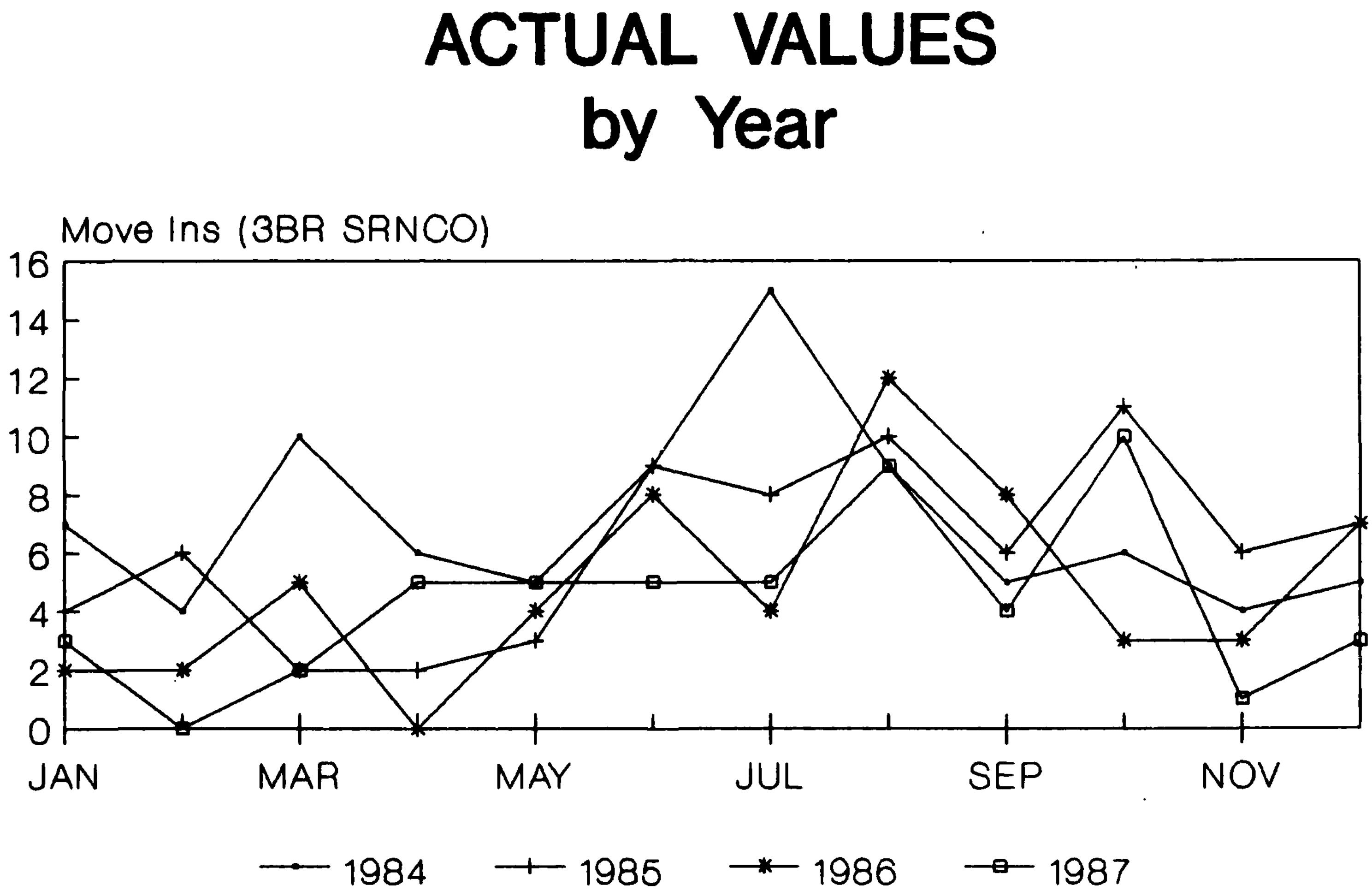


Figure 5. Actual Values for One Class

AVERAGE vs ACTUAL VALUES for 3BR SR NCO

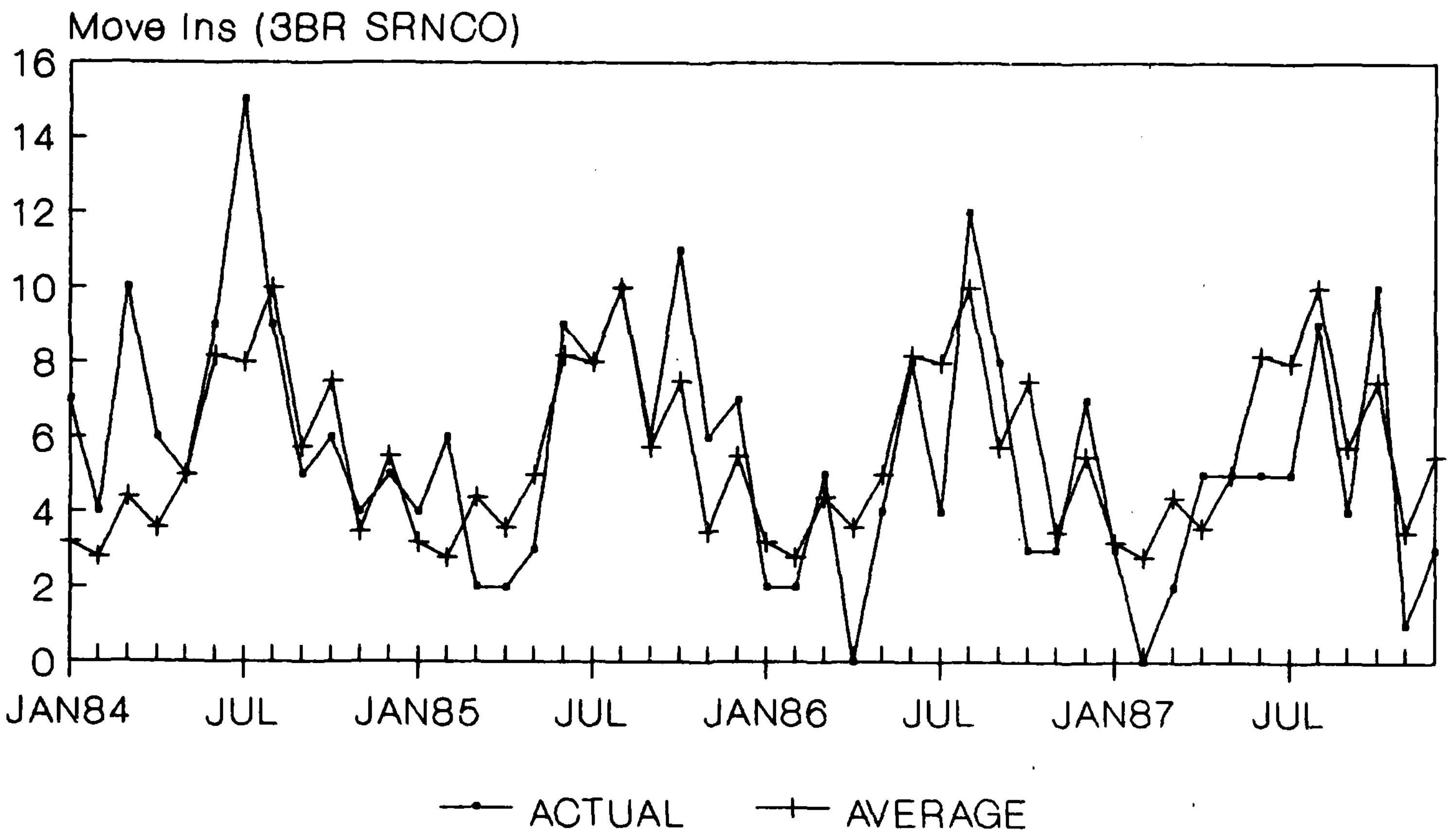


Figure 6. Average vs Actual Values

Seasons for each group tend to overlap. Summer is the biggest time for PCSs and winter is the slowest in all classifications. The comparison of some of the classes can be seen in Figure 7.

Junior NCOs appear to have definite peak periods for PCSs. The first peak occurs in March through April and is followed by a dramatic drop in May before climbing back to the second peak in June. The second peaks lasts through September. The dramatic changes in averages that can occur from one month to the next is illustrated in this case supporting the monthly seasonal choice which follows later.

Junior NCOs appear to have little control over their PCSs. The majority of the moves are in the Spring or Summer months.

Senior NCOs appear to have a much lower and longer peak than do junior NCOs. The senior NCOs' peak starts in June and continues through October. A senior NCO can probably plan to move in the Summer or Fall.

Company grade officers PCS peaks are mainly attributed to graduating classes at the Air Force Institute of Technology (AFIT). The peaks coincide with graduation dates in March, October, and December. The only months which have low PCS rates are January, February, and November.

Field grade officers appear to have better control of when they PCS. The peak season of June through August encompasses almost all of the PCSs for field graders.

AVERAGES FOR ALL NCOs
Including Data from Jan 84 - Jun 88

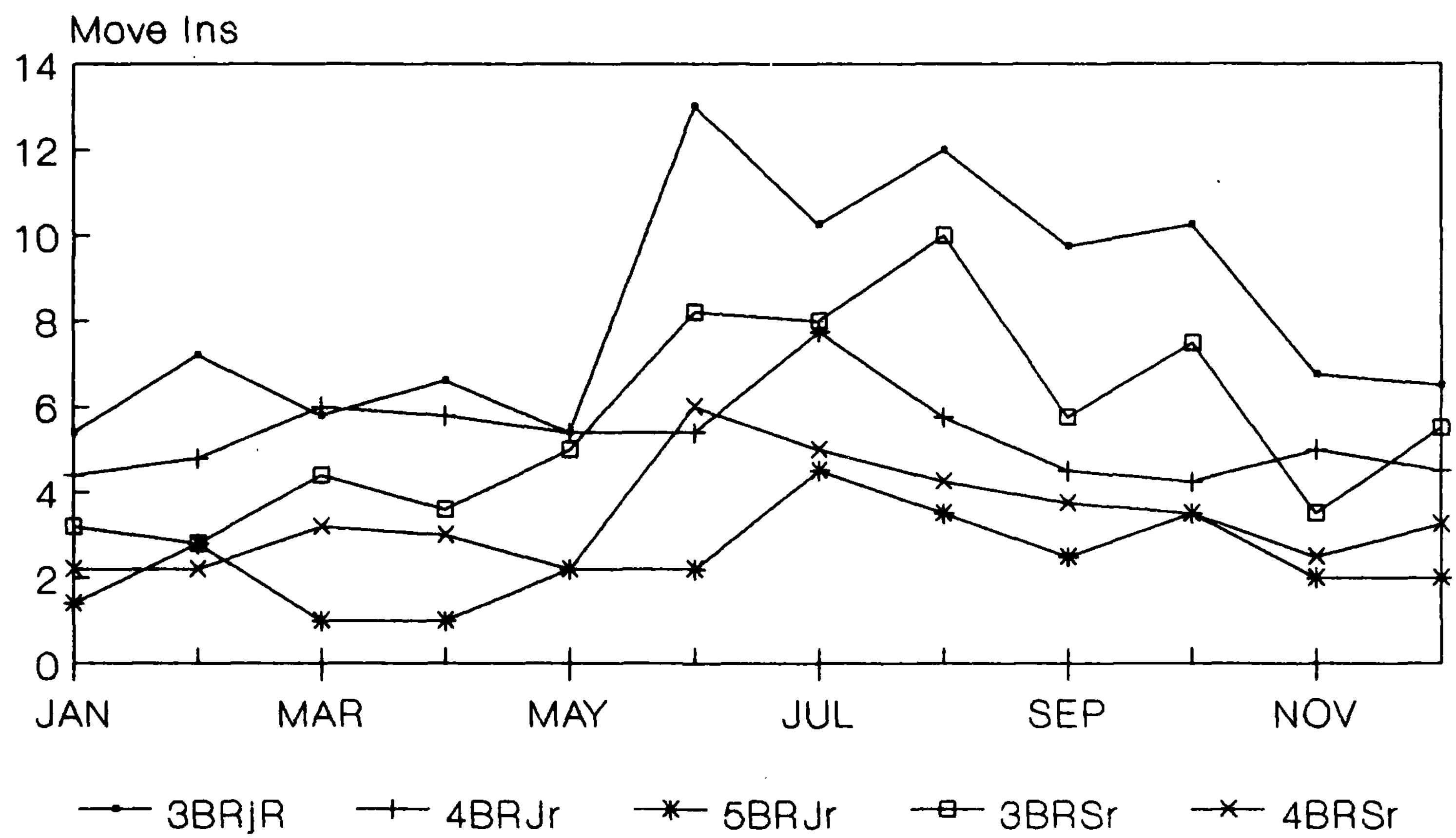


Figure 7. Typical Data

There are small peaks in October and December which are probably caused by graduating AFIT logistics students.

Colonels and generals definitely have the most control over when they move. According to the data, half PCS in the months of July and August with the other half being evenly spread throughout the year.

The overall long term trend common to all categories was the lack of a trend. Housing move-ins tend to remain almost constant from year to year.

There is a definite difference from one month to the next, but not a significant difference between the same months from year to year. The lack of a trend makes the seasonal forecasting method behave almost identically to the monthly average.

Spreadsheet Model

The model was developed on a spreadsheet because of the ease of data manipulation. A spreadsheet also contains some programming potentiality. The macros make the spreadsheet template easy for one who is not familiar with the inner workings. Macros make the spreadsheet data insertion and forecast calculations easy to perform.

The spreadsheet was initially attempted using 20/20[1] on the WANG system in use by Civil Engineering. Because of the difficulty in using 20/20, the lack of documentation, and the

[1] 20/20 is a Trademark of Access Technology, Inc.

slow computer response time, another spreadsheet was chosen. The project was written with VP PLUS, a product of Paperback Software. VP Plus was used because of its ease in graphing and advanced macro capabilities. Macros automatically carry out functions set up by the programmer making the spreadsheet more user friendly. The raw data is located on the same spreadsheet as all of the necessary calculations. Figure 8 is a graphical representation of the locations of each segment of the program on the spreadsheet. The spreadsheet includes the calculations needed to forecast using any of the forecast methods of interest. The following list describes functional breakdown of each segment and corresponds to the capital letters located on Figure 8.

Section A. The raw data is entered and stored in this section. Averages, standard deviations, and seasonal indexes are calculated. The indexes are calculated by dividing the average in the pertinent class over the desired period and dividing by the average computed from section C. The seasonal index weights the month in proportion to the entire yearly average making it possible to use the average to do regression analysis. Once regression is performed, the forecasts for particular months are multiplied by the appropriate seasonal indexes giving the seasonalized forecast.

Section B. All of the spreadsheet macros are located here. This is the only place a user has access to make

changes or add information. The macros ask the user to chose which particular housing list he wants to estimate. Once the waiting list is selected, the macro asks the user a series of questions to set the parameters for the template to work. A copy of section B may be seen in Appendix C. All of the requested data should be readily available to the housing officer with very little further effort.

<u>Section C</u>. The monthly totals are tabulated from the raw data. The entire year for each classification is totaled and the monthly average computed. Dividing the monthly average (section A) by the yearly average produces the seasonal indexes.

<u>Section D</u>. The method of least squares is used to create the foundation for the regression analysis equation. The forecasting line is computed and used in section E.

<u>Section E</u>. The forecast equation uses the regression line developed in section D. The forecast period is entered into the regression equation and a forecast is produced. The forecast is multiplied by the proper seasonal index and the actual forecast is made.

<u>Section F</u>. Location where all forecast are brought together. Also, this is where all vertical look-ups called for by the macros occur. Leasing information is stored here when entered from a macro. Section F includes forecasts made through June 1991.

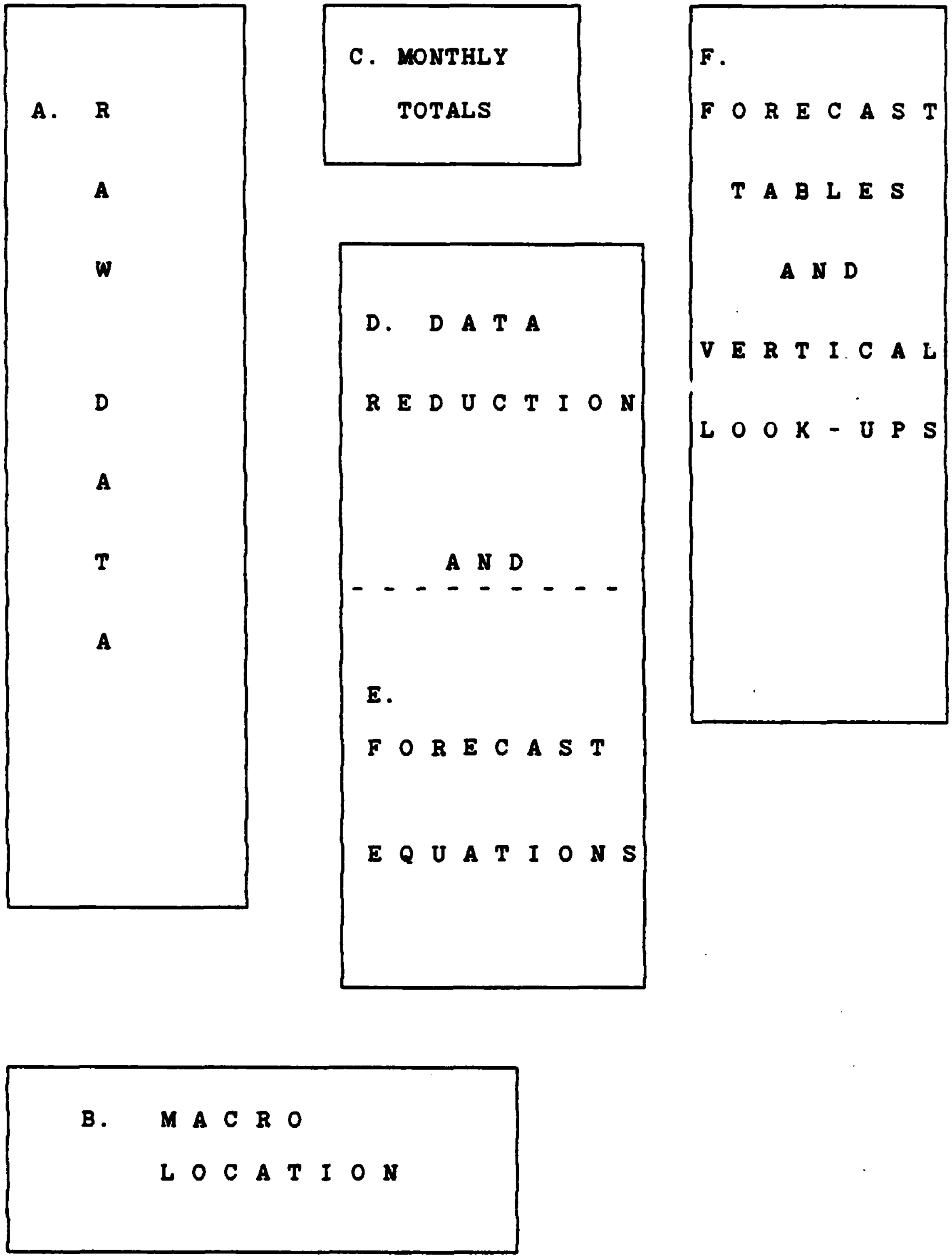


FIGURE 8. SPREADSHEET LAY-OUT

Adjust Seasonally

The data was adjusted seasonally for ease in predicting future values. Monthly seasons were used because of the sometimes steep changes from one month to another.

Evaluations of Methods

Several different forecasting techniques were tested, which included: simple averages, monthly averages, exponential smoothing, seasonal indexing, and modified seasonal indexing. The Mean Absolute Deviation (MAD) acted as the evaluation tool. The lower the MAD the better the method.

Simple averaging consisted of finding the average annual assignment and using that average to forecast future months. If the data were uniform throughout the year, this might be a viable method. However in this case, the simple average resulted in a large MAD (see Table 1).

Monthly averages in each class were used to forecast future months. For example, all January data (Jan 84, Jan 85, Jan 86) for the 3 bedroom Senior Non-commissioned Officers were averaged. That average became the forecast for next January (Jan 87). This produced a surprise because the MAD was very low. The low MAD resulted in the lack of a trend since 1984. As long as there is no trend, monthly averaging appears to be a very good candidate for the model forecasting technique.

CLASS	SEASON	MONTHLY AVERAGE	EXP SMOOTH	YEARLY AVERAGE	ADJUSTED SEASON
JR2	6.32	7.25	7.94	15.94	6.74
JR3	3.76	3.06	4.60	3.74	3.49
JR4	2.90	2.28	3.58	3.23	2.58
JR5	1.57	1.47	2.94	6.31	1.56
SR3	3.78	2.83	2.87	4.32	3.44
SR4	1.72	2.25	3.81	5.31	1.74
CG2	2.65	3.86	2.46	2.40	2.97
CG3	2.26	2.39	2.00	1.25	1.97
CG4	1.95	1.36	1.93	1.90	1.69
FG3	1.69	2.03	2.54	2.25	1.62
FG4	1.35	1.42	.96	2.75	1.35
SG4	1.16	1.61	1.70	2.40	.88
TOTAL	31.11	31.81	37.33	51.80	30.03
AVG	2.59	2.65	3.11	4.32	2.50

Table 1. Mean Absolute Deviations (MADs)

The third method attempted was exponential smoothing. The resulting MAD was lower than simple averaging, but was higher than monthly averaging. Each month was treated separately. For example, June of 1984 through 1986 was used to estimate June of 1987. Each month was independent of all other months. Exponential smoothing forecasts trends, but there are virtually no trends in this data. By the nature of exponential smoothing, the forecast values always lag behind the actual values. Exponential smoothing does not require much historical data because the prediction for the last period is modified by the actual last period and is used in the new forecast.

The fourth method was seasonal indexing. By normalizing each month to a seasonal index number, regression analysis can be performed. Forecasts can be made by transforming the

regression line for future dates for the proper month by the use of the indexes. Seasonal indexing forecasts trends, or in this case, the lack of trends. This particular forecasting method continually uses historical data to build a regression or forecasting line. The results of this method had a low MAD and proved to be very good.

The last method tried was a hybrid of the seasonal index method. The procedure called for adding one half of the prior month's forecast and one half of the next month's forecast to this month's forecast and dividing by two. This approach was taken to smooth sudden peaks that occur one month early or one month late. The data demonstrated that in many cases, one month lower than the forecast was followed by one month higher than the forecast. Any large spikes would be smoothed somewhat by the two adjoining months. This particular procedure also provided a low MAD. By comparing the MADs of these methods, simple averaging and exponential smoothing were discarded. The remaining three methods have MADs relatively close, and any of these methods could be used. See Table 1 for a list of MADs.

Of these three good forecasting methods, the seasonal and adjusted seasonal use linear regression with seasonal indexes. The seasonal method considers trends, but can produce a high MAD when there are skew data. The adjusted seasonal method includes a portion of the preceding and succeeding months to calculate the seasonal index. This

tends to smooth out the estimates. Slopes for the regression analysis used in computing seasonal indexes were practically zero. Figure 9 is a typical regression line calculated through July 1991 for 3 bedroom senior NCOs. These two methods would be better candidates and warrant the more complex calculations if there were larger slopes signifying prominent trends in the data.

The last of the three methods, monthly averaging, is the simplest and yet maintains a low MAD. Being simple, the monthly average has a drawback when compared to the other two; it doesn't respond quickly to trends. Since there are no significant trends, simple monthly averaging is recommended and will be the bases for this model.

Validation

Validation of the model consisted of forecasting values for calender year 1987 using historical data from January 1984 to December 1986 and comparing it to the actual 1987 values. If the actual values were close to the forecast, it was a success. A test was made for each month for each of the twelve lists. Figure 10 illustrates the comparison made for three bedroom NCO quarters. From all lists, there were 57 out of 144 actual values within one standard deviation for a total of forty percent good forecast values. Eighty-seven were more than one standard deviation away from their forecasted values. Those outside of one standard deviation range occurred at random months and rarely did more than two

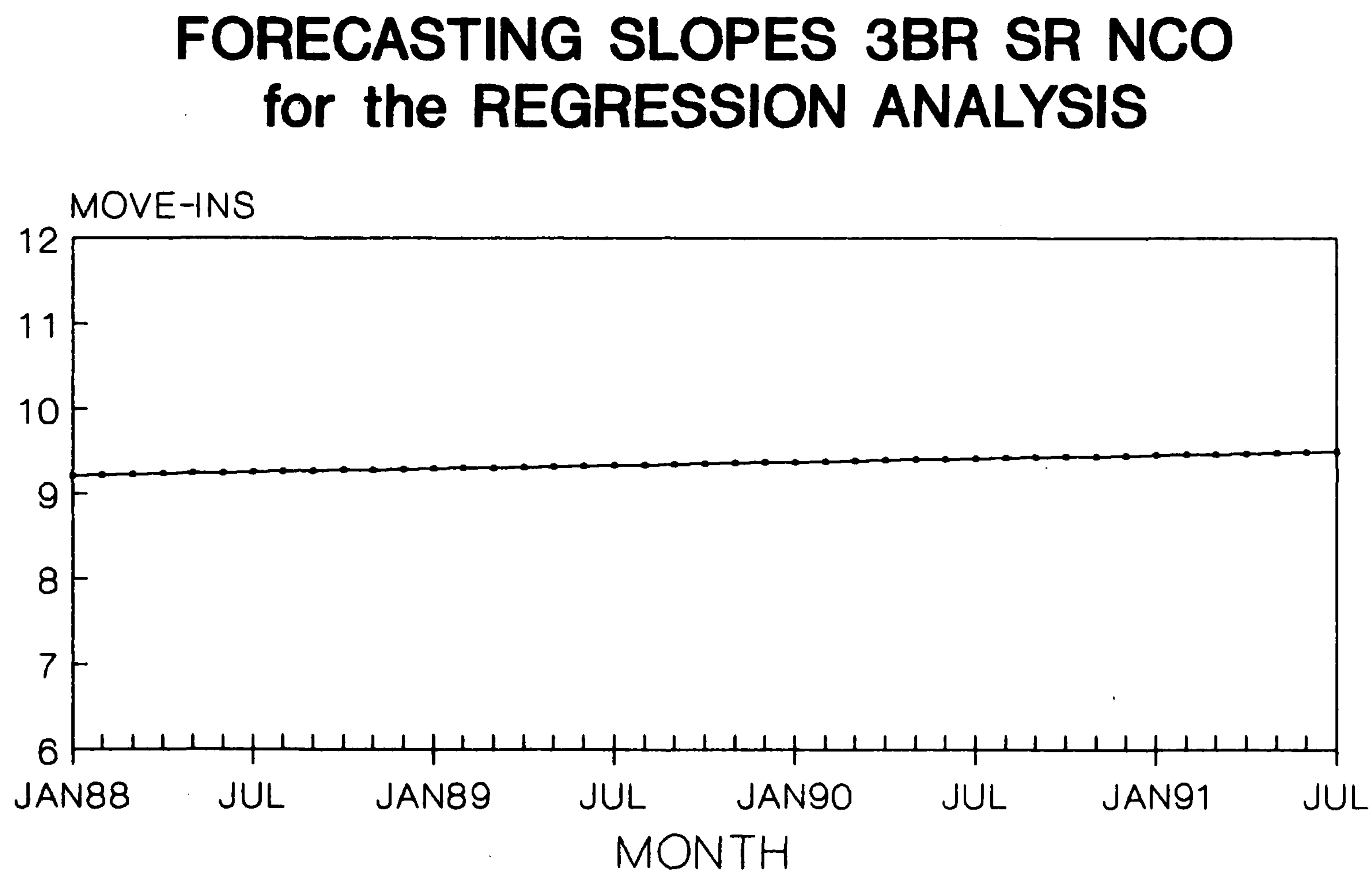


Figure 9. Typical Regression Slope

ONE STANDARD DEVIATION COMPARISON WITH ACTUALS (3BR NCO)

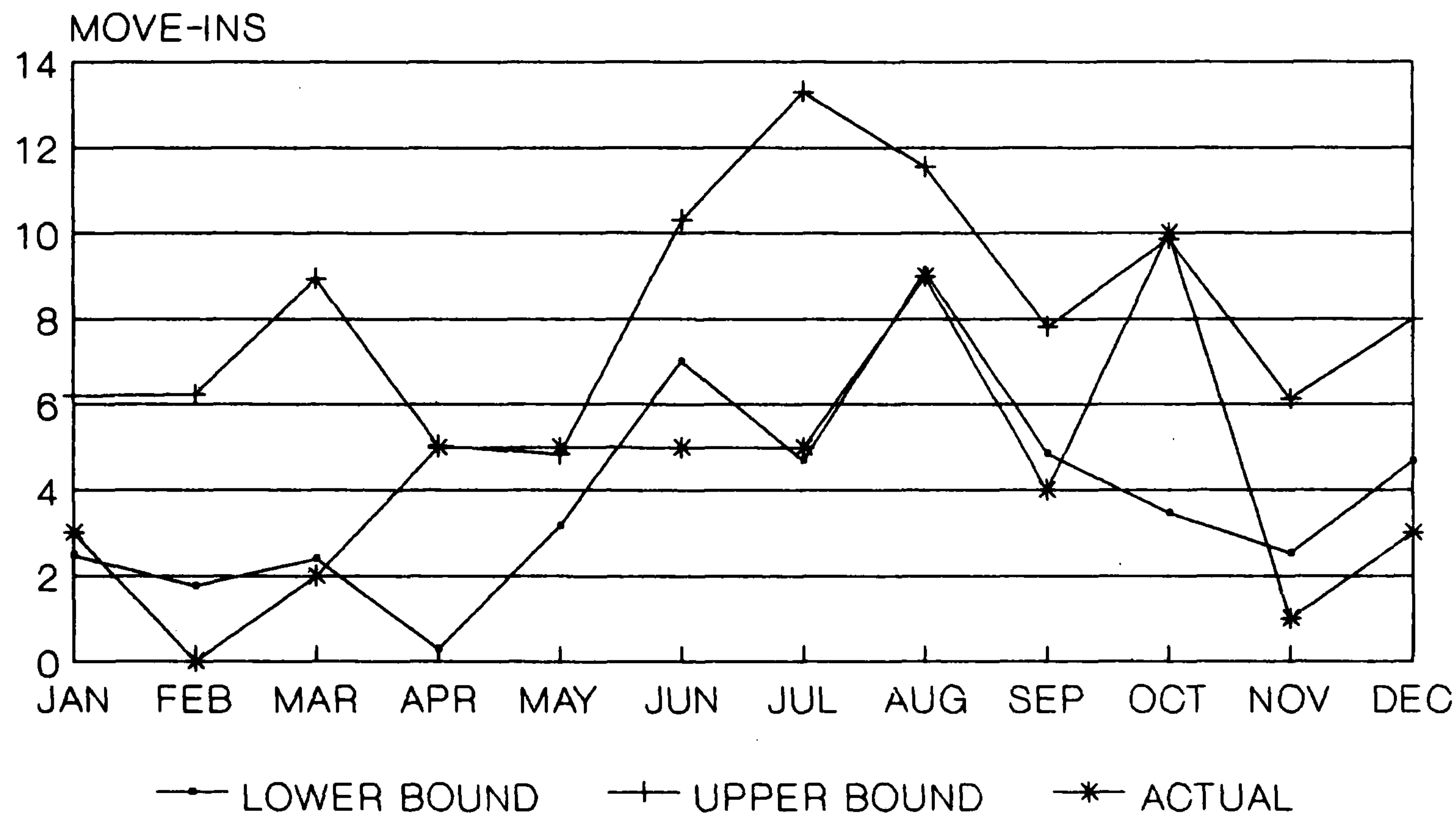


Figure 10. Validation: 1 Std Deviation

values of different classes deviate in the same month.

There were 103 out of 144 actual values within two standard deviations for a total of seventy-two percent good forecast values. Figure 11 characterizes the two standard deviation ranges.

Estimation of Waiting Time

The accurate forecasting of housing turn over can now be easily summed by the spreadsheet program from the present into the future. The output consists of the month and the year of the projected assignment. The user only sees the instruction page (see Appendix C) while the program is running. The first value returned is the forecast without considering those people ahead on the list who still are restricted by leases beyond the forecast assignment date. If the number of people who are restricted by leases beyond the forecast assignment date for the client is known, the menu option "Lease" may be used. The forecast is most accurate when the lease option is properly utilized. This forecast date can be given to the customer as the best estimate.

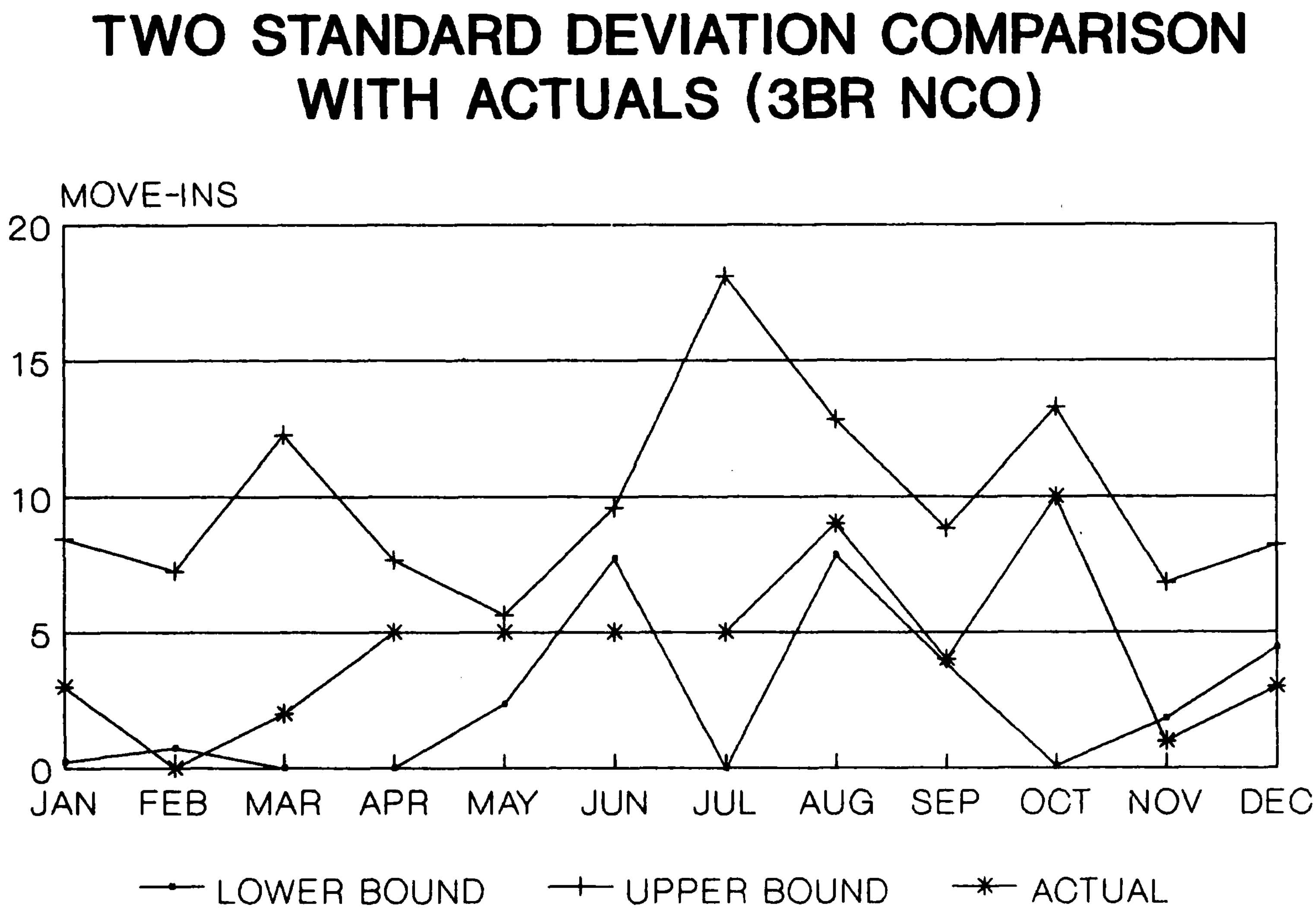


Figure 11. Validation: 2 Std Deviations

V. Conclusion

Successes

There were several successes developed during this research. First, and foremost, this forecasting method works. The forecast values approximate calendar year 1987 very closely. The algorithm developed by this thesis will be implemented throughout the Air Force via the Work Information Management System (WIMS). Ray Grimm, in conjunction with the Air Force Engineering and Services Center, is developing the algorithm in COBOL. There are now forecasting methods that can estimate how many people will be assigned each month to military family housing. The three forecasting methods of monthly averaging, seasonal indexing, and adjusted seasonal indexing proved to be good techniques.

Failures

Several different avenues were attempted before the final outcome was achieved. The first notion of accomplishing this task on the WANG was rejected, but as mentioned above is being implemented on the WANG by others.

Ideally, the validation phase should follow applicants in each housing category from the time they are put on the list until they were assigned a house. If the assignment came within two standard deviations of the forecast which was given to the applicant when he applied for housing, then it

was a success. If the forecast was outside of this range, then further evaluation of the model for possible outliers in the historical data need to be made. However, since several waiting lists have waiting time greater than six months, time would not permit this type of validation.

The spreadsheet template had to be broken into two parts: one for enlisted personnel and one for officers. The split was necessary because the size of the combined spreadsheets occupied all of the available computer memory. The two separate templates are now much more manageable.

The use of the spreadsheet had several other problems. The first was the macro usage. The building of macros is very time consuming and has limited use. Macros make template use very user friendly, but is easy to stall. Inputs out of the relevant ranges could be typed in and cause erroneous or nonsense answers. The spreadsheet has little or no self checking data entry systems and new data input is arduous. Space could be allocated for new data, but some of the ranges and calculations would have to be manually input. Therefore, the person inputting new data would have to be intimately familiar with the template.

Future Research

This forecasting model has proven successful. With the addition of WIMS to Civil Engineering, the data base is readily available and ripe for use in this fashion.

1. Develop a program to look at the WIMS data base, use a forecasting method, and automatically update itself when new data is added to the data base.

2. Modify the waiting time estimate given to the applicant to include a probable range of waiting time (eg. 3 - 6 months).

3. Forecast by tapping into the master base personnel data base. See first hand who is leaving and arriving when.

4. Go one step further than number two. Tip into the master personnel files at MPC and get the PCS news as it happens.

Copies of the spreadsheet may be obtained by writing the Engineering Management Course Director at the Air Force Institute of Technology School of Systems and Logistics at Wright-Patterson AFB, Ohio 45433.

Appendix A

This is a record of the data collected from Wright Patterson AFB OH. The following data was used as the historical data to drive the models. The values of total (TOT), average (AVG), seasonal index (S.I.), and standard deviation (STD) were calculated from the proper years. When validating, only data from 1984 through 1986 were used. The actual model uses all available data to make a forecast.

JANUARY

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	29	7	7	1	7	2
1985	19	8	3	1	4	5
1986	22	8	6	4	2	1
1987	29	2	6	1	3	2
1988	2	2	0	0	0	1
TOT	101	27	22	7	16	11
AVG	20.2	5.4	4.4	1.4	3.2	2.2
S.I.	.74	.59	.74	.54	.52	.58
STD	4.38	2.49	1.50	1.30	1.87	1.50

FEBRUARY

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	17	10	3	5	4	3
1985	16	6	4	2	6	0
1986	16	5	4	3	2	3
1987	15	4	6	3	0	1
1988	22	11	7	1	2	4
TOT	86	36	24	14	14	11
AVG	17.2	7.2	4.8	2.8	2.8	2.2
S.I.	.63	.79	.81	1.08	.45	.58
STD	.71	2.28	1.09	1.09	2.24	1.30

MARCH

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	31	4	9	2	10	6
1985	32	5	9	2	2	2
1986	30	9	2	0	5	1
1987	24	7	6	1	2	4
1988	33	4	4	0	3	3
TOT	150	29	30	5	22	16
AVG	30.0	5.8	6.0	1.0	4.4	3.2
S.I.	1.10	.63	1.01	.38	.71	.84
STD	3.11	1.92	2.87	.83	3.27	1.92

APRIL

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	30	4	10	0	6	5
1985	30	8	7	3	2	1
1986	18	5	6	1	0	1
1987	38	8	3	0	5	5
1988	45	8	3	1	5	3
TOT	161	33	29	5	18	15
AVG	32.2	6.6	5.8	1.0	3.6	3.0
S.I.	1.18	.72	.97	.38	.58	.79
STD	7.14	1.79	2.50	1.22	2.38	2.00

MAY

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	20	6	8	3	5	2
1985	11	11	3	4	3	3
1986	24	5	3	1	4	3
1987	22	4	8	1	5	0
1988	14	1	5	2	8	3
TOT	91	27	27	11	25	11
AVG	18.2	5.4	5.4	2.2	5.0	2.2
S.I.	.67	.59	.91	.84	.81	.58
STD	4.97	2.69	2.50	1.30	.83	1.22

JUNE

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	28	17	9	0	9	4
1985	26	12	6	3	9	5
1986	26	15	5	1	8	9
1987	29	6	6	5	5	8
1988	9	15	1	2	10	4
TOT	118	65	27	11	41	30
AVG	23.6	13.0	5.4	2.2	8.2	6.0
S.I.	.86	1.42	.91	.84	1.33	1.57
STD	1.30	4.15	1.50	1.92	1.64	2.06

JULY

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	24	9	13	9	15	10
1985	25	13	8	4	8	6
1986	22	6	4	3	4	3
1987	25	13	6	2	5	1
TOT	96	41	31	18	32	20
AVG	24.0	10.3	7.8	4.5	8.0	5.0
S.I.	.88	1.12	1.30	1.73	1.29	1.31
STD	1.22	2.95	3.34	2.69	4.30	3.39

AUGUST

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	28	8	8	5	9	9
1985	36	14	5	4	10	4
1986	26	11	5	2	12	1
1987	25	15	5	3	9	3
TOT	115	48	23	14	40	17
AVG	28.8	12.0	5.8	3.5	10.0	4.3
S.I.	1.05	1.31	.97	1.34	1.62	1.11
STD	4.32	2.74	1.30	1.12	1.22	2.95

SEPTEMBER

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	31	9	7	4	5	4
1985	37	9	3	4	6	3
1986	26	12	5	0	8	5
1987	22	9	3	2	4	3
TOT	116	39	18	10	23	15
AVG	29.0	9.8	4.5	2.5	5.8	3.8
S.I.	1.06	1.07	.76	.96	.93	.98
STD	5.61	1.30	1.66	1.66	1.48	.83

OCTOBER

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	23	8	4	4	6	4
1985	22	10	6	4	11	3
1986	30	10	4	3	3	4
1987	31	13	3	3	10	3
TOT	106	41	17	14	30	14
AVG	26.5	10.3	4.3	3.5	7.5	3.5
S.I.	.97	1.12	.71	1.34	1.21	.92
STD	4.03	1.79	1.09	.50	3.20	.50

NOVEMBER

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	14	5	3	1	4	0
1985	27	6	6	3	6	3
1986	24	12	5	4	3	5
1987	11	4	6	0	1	2
TOT	76	27	20	8	14	10
AVG	19.0	6.8	5.0	2.0	3.5	2.5
S.I.	.69	.74	.84	.77	.57	.66
STD	6.67	3.11	1.22	1.58	1.80	1.80

DECEMBER

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
1984	22	9	4	1	5	4
1985	29	6	5	2	7	2
1986	27	8	7	3	7	4
1987	19	3	2	2	3	3
TOT	97	26	18	8	22	13
AVG	24.3	6.5	4.5	2.0	5.5	3.3
S.I.	.89	.71	.76	.77	.89	.85
STD	3.96	2.29	1.80	.71	1.66	.83

JANUARY

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	6	3	4	1	0	0
1985	6	1	0	4	2	1
1986	2	1	0	5	2	1
1987	9	4	4	2	0	0
1988	4	5	2	3	4	2
TOT	27	14	10	15	8	4
AVG	5.4	2.8	2.0	3.0	1.6	.8
S.I.	.78	.55	.86	.63	.80	.31
STD	2.49	1.30	2.00	1.58	1.00	.50

FEBRUARY

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	2	2	4	2	1	0
1985	2	2	3	1	1	2
1986	1	1	2	1	0	3
1987	2	3	1	1	1	0
1988	7	2	2	1	1	0
TOT	14	5	9	4	2	5
AVG	2.8	1.8	2.6	1.2	.8	1.3
S.I.	.41	.35	1.11	.25	.38	.52
STD	.43	.71	1.12	.43	.43	1.30

MARCH

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	4	3	5	2	0	0
1985	11	9	2	1	2	1
1986	9	1	3	2	0	0
1987	4	4	0	2	1	0
1988	10	3	1	1	2	0
TOT	38	20	11	8	5	1
AVG	7.6	4.0	2.2	1.6	1.0	.2
S.I.	1.10	.79	.94	.34	.50	.08
STD	3.08	2.95	1.80	.43	.83	.43

APRIL

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	12	1	2	2	1	0
1985	9	5	1	3	5	1
1986	3	4	2	2	1	0
1987	3	3	3	4	0	1
1988	8	2	1	2	0	0
TOT	35	15	9	13	7	2
AVG	7.0	3.0	1.8	2.6	1.4	.4
S.I.	1.02	.59	.77	.54	.70	.16
STD	3.90	1.48	.71	.83	1.92	.50

MAY

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	7	9	6	3	2	0
1985	10	5	2	2	0	0
1986	4	2	1	2	2	3
1987	2	3	2	2	1	1
1988	5	1	0	2	0	2
TOT	28	20	11	11	5	6
AVG	5.6	4.0	2.2	2.2	1.0	1.2
S.I.	.81	.79	.94	.46	.50	.47
STD	3.03	2.68	1.92	.43	.83	1.22

JUNE

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	5	6	2	8	5	8
1985	3	8	2	6	3	2
1986	7	8	4	14	2	3
1987	6	6	4	6	4	2
1988	9	8	2	13	8	3
TOT	30	36	14	47	22	18
AVG	6.0	7.2	2.8	9.4	4.4	3.6
S.I.	.87	1.42	1.20	1.97	2.20	1.42
STD	1.48	1.00	1.00	3.28	1.12	2.49

JULY

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	6	6	5	6	6	8
1985	5	10	1	15	4	11
1986	3	9	2	6	1	10
1987	3	2	2	9	1	7
TOT	17	27	10	36	12	36
AVG	4.3	6.8	2.5	9.0	3.0	9.0
S.I.	.62	1.33	1.07	1.89	1.50	3.54
STD	1.30	3.11	1.50	3.67	2.12	1.58

AUGUST

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	9	5	2	7	5	7
1985	3	7	3	7	0	5
1986	7	6	4	5	4	6
1987	7	7	2	10	1	4
TOT	26	25	11	29	10	22
AVG	6.5	6.3	2.8	7.3	2.5	5.5
S.I.	.94	1.23	1.18	1.52	1.25	2.16
STD	2.18	.83	.83	1.79	2.06	1.12

SEPTEMBER

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	9	5	1	4	0	2
1985	8	4	2	7	3	3
1986	4	3	1	1	3	1
1987	8	3	0	1	1	3
TOT	29	15	4	13	7	9
AVG	7.3	3.8	1.0	3.3	1.8	2.3
S.I.	1.05	.74	.43	.68	.88	.89
STD	1.92	.83	.71	2.49	1.30	.83

OCTOBER

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	2	11	2	5	3	6
1985	15	2	4	9	2	1
1986	12	5	3	7	2	1
1987	4	6	1	4	1	1
TOT	33	24	10	25	8	9
AVG	8.3	6.0	2.5	6.3	2.0	2.3
S.I.	1.20	1.19	1.07	1.31	1.00	.89
STD	5.40	3.24	1.12	1.92	.71	2.17

NOVEMBER

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	1	1	1	3	3	5
1985	5	1	1	1	0	1
1986	4	3	2	2	1	0
1987	3	3	1	3	0	1
TOT	13	8	5	9	4	7
AVG	3.3	2.0	1.3	2.3	1.0	1.8
S.I.	.47	.40	.54	.47	.50	.69
STD	1.48	1.00	.43	.83	1.22	1.92

DECEMBER

	CGO			FGO		SR/G
	2BR	3BR	4BR	3BR	4BR	3/4
1984	7	10	2	4	1	0
1985	6	10	3	6	5	1
1986	17	9	1	4	0	0
1987	11	5	2	5	0	2
TOT	41	34	8	19	6	3
AVG	10.3	8.5	2.0	4.8	1.5	.8
S.I.	1.49	1.68	.86	1.00	.75	.30
STD	4.32	2.06	.71	.83	2.06	.83

Appendix B

The following tables are the tabulized standard deviations by classification, by month.

MONTHLY STANDARD DEVIATIONS

	JR NCO				SR NCO	
	2BR	3BR	4BR	5BR	3BR	4BR
JAN	4.4	2.5	1.5	1.3	1.9	1.5
FEB	.7	2.3	1.1	1.1	2.2	1.3
MAR	3.1	1.9	2.9	.8	3.3	1.9
APR	7.1	1.8	2.5	1.2	2.4	2.0
MAY	5.0	2.7	2.5	1.3	.8	1.2
JUN	1.3	4.2	1.5	1.9	1.6	2.1
JUL	1.2	2.9	3.3	2.7	4.3	3.4
AUG	4.3	2.7	1.3	1.1	1.2	2.9
SEP	5.6	1.3	1.7	1.7	1.5	.8
OCT	4.0	1.8	1.1	.5	3.2	.5
NOV	6.7	3.1	1.2	1.6	1.8	1.8
DEC	4.0	2.3	1.8	.7	1.7	.8
1 DEV	3.95	2.46	1.87	1.33	2.16	1.69
2*STD	7.91	4.92	3.73	2.65	4.32	3.38

MONTHLY STANDARD DEVIATIONS

	COMPANY GRADE			FIELD GRADE		SR/GEN
	2BR	3BR	4BR	3BR	4BR	4BR
JAN	2.5	1.3	2.0	1.6	1.0	.5
FEB	.4	.7	1.1	.4	.4	1.3
MAR	3.1	2.9	1.8	.4	.8	.4
APR	3.9	1.5	.7	.8	1.9	.5
MAY	3.0	2.7	1.9	.4	.8	1.2
JUN	1.5	1.0	1.0	3.3	1.1	2.5
JUL	1.3	3.1	1.5	3.7	2.1	1.6
AUG	2.2	.8	.8	1.8	2.1	1.1
SEP	1.9	.8	.7	2.5	1.3	.8
OCT	5.4	3.2	1.1	1.9	.7	2.2
NOV	1.5	1.0	.4	.8	1.2	1.9
DEC	4.3	2.1	.7	.8	2.1	.8
1 DEV	2.58	1.77	1.15	1.54	1.30	1.24
2*STD	5.17	3.53	2.31	3.09	2.60	2.48

Appendix C

The following is a typical macro. The text portion is what the user actually sees when running the program. The mixture of letters, numbers, and symbols below that is the actual code for the macro that forecasts the date for the classification requested.

```
============================================================

          Housing Office Move-in Estimating System (HOMES)

============================================================


          Welcome to HOMES! This spreadsheet will estimate
          the waiting time for enlisted applicants.

          1.  Which waiting list.

          2.  For this class, what percentage accepts.

          3.  What date do you wish to estimate from.  All
              dates must be later than 30 JUN 88 or 6/30/88.

          4.  You will need the number of leases that are
              still active by the people above in the list
              and what months those applicants' leases
              terminate.  For example, if the initial
              estimate is for June 1988, then count how many
              leases are in the newly estimated month and run
              the lease part again.
```

Macro that completes all forecasting:

```
AJr2  BJr3    CJr4    DJr5    ESr3
/xnWhat month do you wish to estimate from?  (ex. 1 for
Jan)~B282~/xnWhat day?  (ex. 5 for fifth)~C282~/xnWhat year?
(Ex. 88 for 1988)~D282~/xnWhat position is applicant on
list?~C284~/xnFor this class what percentage accepts when
offered? (ex. .90 for 90%)~B284~{F9}/xmH291~
```

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[redacted]

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT
Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
AFIT/GEM/LSM/88S-12

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
School of Systems and Logistics

6b. OFFICE SYMBOL (If applicable)
AFIT/LSM

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and ZIP Code)
Air Force Institute of Technology
Wright-Patterson AFB OH 45433-6583

7b. ADDRESS (City, State, and ZIP Code)

8a. NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (If applicable)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
HOMES: THE HOUSING OFFICE MOVE-IN ESTIMATING SYSTEM

12. PERSONAL AUTHOR(S)
Franklin L. Myers, B.S., Captain, USAF

13a. TYPE OF REPORT
MS Thesis

13b. TIME COVERED
FROM ________ TO ________

14. DATE OF REPORT (Year, Month, Day)
1988 September

15. PAGE COUNT
67

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
13	02	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Families, THESES, Housing (Dwellings), Forecasting, Statistical Analysis. (JE)
Military Facilities

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Thesis Chairman: James R. Holt, Major, USAF
Assist Prof of Engrg Mgt

Approved for public release IAW AFR 190-1.

WILLIAM A. MAUER 17 Oct 88
Associate Dean
School of Systems and Logistics
Air Force Institute of Technology (AU)
Wright-Patterson AFB OH 45433

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL
James R. Holt, Major, USAF

22b. TELEPHONE (Include Area Code)
(513) 255-5023

22c. OFFICE SYMBOL
AFIT/LSM

DD Form 1473, JUN 86 — Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

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ABSTRACT

The purpose of this study was to utilize a forecast method for estimating waiting time for Military Family Housing. The study had two basic objectives. The first was to accurately forecast waiting time for each classification of Military Family Housing and the second was to create a user friendly, statistically based computer program to implement the forecasting technique.

The study surfaced three quantitative methods that forecast waiting time successfully: Seasonal indexing, adjusted seasonal indexing, and monthly averaging. Analysis proved that these three methods were the most accurate of the forecasting methods tried and any one should produce satisfactory forecasts.

Monthly averaging was the method chosen for the forecasting model. That particular method was chosen for its accuracy and relative simplicity of the calculations. Monthly averaging worked well because there were virtually no trends in the assignment process. The two indexing methods utilize regression analysis for the forecast and when there is a zero slope, the forecast value is practically identical with the average.

The model runs on VP Plus, a spreadsheet that is IBM compatible. The use of macros within the spreadsheet make the program user friendly. The spreadsheet template is configured for Wright-Patterson AFB OH, but may easily be adapted to any other base with similar waiting lists.

Ray Grimm, WIMS Systems Director for Patrick AFB, in conjunction with the Air Force Engineering and Services Center, is currently using the algorithm as a basis for writing a COBOL program for use on the WANG computer.

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